General

Guideline Title

ACR Appropriateness Criteria® abdominal aortic aneurysm: interventional planning and follow-up.

Bibliographic Source(s)

Francois CJ, Skulborstad EP, Majdalany BS, Chandra A, Collins JD, Farsad K, Gerhard-Herman MD, Gornik HL, Kendi AT, Khaja MS, Lee MH, Sutphin PD, Kapoor BS, Kalva SP, Expert Panels on Vascular Imaging and Interventional Radiology. ACR AppropriatenessÂ® abdominal aortic aneurysm: interventional planning and follow-up. Reston (VA): American College of Radiology (ACR); 2017. 13 p. [100 references]

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Francois CJ, Kramer JH, Rybicki FJ, Ray CE Jr, Bandyk DF, Burke CT, Dill KE, Gerhard-Herman MD, Hanley M, Hohenwalter EJ, Mohler ER III, Rochon PJ, Schenker MP, Expert Panel on Vascular Imaging and Interventional Radiology. ACR Appropriateness Criteria® abdominal aortic aneurysm: interventional planning and follow-up. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 8 p. [71 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

NEATS Assessment

National Guideline Clearinghouse (NGC) has assessed this guideline's adherence to standards of trustworthiness, derived from the Institute of Medicine's report Clinical Practice Guidelines We Can Trust.

= Poor = Fair = Good = Very Good = Excellent

Assessment	Standard of Trustworthiness
YES	Disclosure of Guideline Funding Source
	Disclosure and Management of Financial Conflict of Interests

	Guideline Development Group Composition
YES	Multidisciplinary Group
YES	Methodologist Involvement
▮▯▯▯▯	Patient and Public Perspectives
	Use of a Systematic Review of Evidence
▮▮▮▮▮	Search Strategy
▮▮▮▯▯	Study Selection
▮▮▮▮▯	Synthesis of Evidence
	Evidence Foundations for and Rating Strength of Recommendations
▮▮▯▯▯	Grading the Quality or Strength of Evidence
▮▮▮▮▮	Benefits and Harms of Recommendations
▮▮▮▮▮	Evidence Summary Supporting Recommendations
▮▮▮▮▯	Rating the Strength of Recommendations
▮▮▮▮▮	**Specific and Unambiguous Articulation of Recommendations**
▮▯▯▯▯	**External Review**
▮▮▮▯▯	**Updating**

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Abdominal Aortic Aneurysm (AAA): Interventional Planning and Follow-up

Variant 1: Planning for pre-endovascular repair (EVAR) or open repair of AAA.

Procedure	Appropriateness Category	Relative Radiation Level
CTA abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢☢☢
MRA abdomen and pelvis without and with IV contrast	Usually Appropriate	O
MRA abdomen and pelvis without IV contrast	May Be Appropriate	O
CT abdomen and pelvis with	May Be Appropriate	☢☢☢☢

Procedure	Appropriateness Category	Relative Radiation Level
IV contrast		
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢☢
Aortography abdomen	May Be Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
US aorta abdomen with duplex Doppler	Usually Not Appropriate	O
X-ray abdomen and pelvis	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast and US aorta abdomen with duplex Doppler	Usually Not Appropriate	☢☢☢☢

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Follow-up for post-endovascular repair (EVAR) or open repair of AAA.

Procedure	Appropriateness Category	Relative Radiation Level
CTA abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢☢☢
MRA abdomen and pelvis without and with IV contrast	Usually Appropriate	O
Aortography abdomen	May Be Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast and US aorta abdomen with duplex Doppler	May Be Appropriate	☢☢☢☢
MRA abdomen and pelvis without IV contrast	May Be Appropriate	O
US aorta abdomen with duplex Doppler	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢☢
CT abdomen and pelvis with IV contrast	May Be Appropriate (Disagreement)	☢☢☢☢
X-ray abdomen and pelvis	May Be Appropriate	☢☢☢

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

In 1991, a group of investigators reported successful deployment of an endoluminal stent graft within the aorta via a transfemoral approach. It permanently transformed the landscape of AAA management and therapy. Previous treatment options were limited to expectant management combining medical blood pressure control with close imaging surveillance versus traditional open surgical repair. Given the significant perioperative morbidity of open repair, the point of transition to surgical intervention varied on a case-by-case basis. Guidelines for AAA screening were subsequently established to assist medical decision making. These guidelines were developed based on a patient's health status, comorbidities, the aneurysm's maximum diameter (>5.5 cm) and rate of change (>1 cm/year) and other signs that indicated impending rupture. The arrival of the endovascular aneurysm repair (EVAR) technique introduced new

variables to managing AAAs. Relatively recent development of the fenestrated endovascular aneurysm repair (FEVAR) and percutaneous endovascular aneurysm repair (PEVAR) has advanced therapeutic potential while maintaining low morbidity.

Multiple studies have shown significantly decreased length of hospital stay and decreased perioperative morbidity with EVAR compared to open repair. Despite this, open repair is still performed in patients with unsuitable aneurysm morphology for EVAR and in those with failed EVAR. For patients who present de novo for treatment of AAA without any prior imaging available, the entire aorta (including the thoracic portion) should be assessed to fully characterize the aneurysm and to exclude a concomitant thoracic aortic aneurysm. Preoperative imaging for open repair of AAA has one primary focus: to determine the need for surgery based on aneurysm size, extent, and rate of growth. Additional information regarding potential variant anatomy can also be helpful in guiding appropriate treatment and preventing unexpected complications at the time of repair.

EVAR requires accurate preoperative imaging evaluation for appropriate patient selection based on aneurysm morphology, access vessel size, and patency. Paramount considerations in evaluating an AAA for EVAR lie in the morphology of the proximal neck, which for an infrarenal AAA is defined as the segment of aorta between the most caudal renal artery and the proximal boundary of the aneurysm. Unfavorable neck anatomy, based on its diameter, length, angulation, morphology, and presence of calcification, is the most frequent cause of exclusion from EVAR. Over 50% of patients have aneurysm morphology unsuitable for conventional EVAR. In conventional EVAR, a neck size of >10 to 15 mm in length and <30 mm in diameter is required to provide an adequate proximal graft seal. Although not an absolute contraindication to EVAR, mural thrombus and atherosclerotic calcification covering more than 90º of the circumference of the aortic diameter in the proximal neck is associated with a higher risk for type I endoleak and stent-graft migration. The distal landing zone is usually located within one or both of the common iliac arteries. With newer-generation devices, common iliac artery diameters of ≤20 mm can be considered for EVAR. The minimal external iliac artery intraluminal diameter should be ≥7 mm to safely accept delivery sheaths.

In recent years, new devices have become available to mitigate unfavorable aortic neck anatomy. Several designs feature an uncovered proximal portion that allows for placement of the stent directly at the origin of aortic branches, whereas others possess ready-made vessel origins for placement within the renal and mesenteric arteries. FEVAR is an alternative approach for those with aortic necks of inadequate length. In FEVAR, fenestrations within the graft material allow for perfusion of major visceral arteries while securing an adequate proximal seal. A variant of the FEVAR technique describes the placement of bridging stents through these fenestrations. Such devices may be especially favorable in women, as these patients are less likely to have aneurysm neck and iliac diameters sufficient for traditional EVAR. FEVAR obviates the need for open femoral exposure and offers the benefit of shorter procedure times, lower complication rates, and shorter hospital stays. FEVAR requires common femoral artery anatomy that is suitable for percutaneous access and free of significant calcification. Candidates for FEVAR should be carefully selected, as the presence and degree of vessel calcification is a major determinant of technical failure.

The advantages of EVAR come at a cost of lifelong imaging surveillance. This is due to higher rate of complications that require reintervention compared to open repair. Complications of EVAR include stent graft migration, kinking, infection, thrombosis, and renal dysfunction. The most important complication to detect is continued aneurysm expansion leading to eventual rupture, which can occur even after successful EVAR. The most common complication of EVAR is endoleak formation, which may contribute to aneurysm sac enlargement and rupture. Endoleaks are classified by their etiology, with types I and III most commonly leading to rupture. Appropriate classification is therefore crucial for subsequent management and should be clarified whenever possible. Although EVAR is safe and has a low mortality rate, the possibility of complications and need for reintervention remains high, thereby requiring life-long monitoring.

The ultimate goal of endovascular therapy is to prevent aneurysm rupture. Follow-up imaging is the most useful tool for evaluating post-therapeutic outcomes and monitoring potential complications. Successful therapy results in an aneurysm that remains stable or decreases in size over serial follow-up imaging

examinations, with decreasing size of the aneurysm sac believed to indicate a low risk of future rupture All available imaging modalities have been investigated over time for their efficacy in post-EVAR follow-up. According to Society of Interventional Radiology guidelines, the imaging modality of choice should allow at least (1) measurement of aortic aneurysm diameter, (2) detection and classification of endoleaks, and (3) detection of morphologic details of the stent grafts. Imaging modalities should be assessed by their effectiveness in satisfying these three parameters, as well as their respective safety profiles, including use of ionizing radiation and potentially nephrotoxic contrast material.

Overview of Imaging Modalities

CT and CTA

Computed tomography (CT) is a cross-sectional imaging modality that offers excellent spatial resolution, fast image acquisition times, and widespread availability. However, without contrast material administration, its ability to assess vascular structures is limited. Evaluation of the vessel lumen is accomplished through CT angiography (CTA), a technique that utilizes the administration of iodinated contrast material. The addition of 3-D volumetric postprocessing techniques allow the abdominal aorta and associated vasculature to be viewed in any obliquity and affords quantification of luminal diameter, cross-sectional area, and sac volume. A disadvantage of CTA includes potential nephrotoxicity from administered contrast material.

For the purposes of distinguishing between CT and CTA, the ACR Appropriateness Criteria topics use the definition in the Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography (CTA) : "*CTA uses a thin-section CT acquisition that is timed to coincide with peak arterial or venous enhancement. The resultant volumetric dataset is interpreted using primary transverse reconstructions as well as multiplanar reformations and 3D renderings*."

All procedure elements are essential: (1) timing, (2) recons/reformats, and (3) 3-D renderings. Standard CTs with contrast also include timing issues and recons/reformats. Only in CTA, however, is 3-D rendering a required element. This corresponds to the definitions that the Centers for Medicare & Medicaid Services (CMS) has applied to the Current Procedural Terminology (CPT) codes.

CTA imaging may be performed as a single arterial phase, biphasic study (noncontrast and arterial or arterial and delayed phases), or as a triphasic study (noncontrast, arterial, and delayed phases). To reduce the cumulative lifetime radiation dose of patients undergoing CTA surveillance, several authors have proposed eliminating either the arterial phase or delayed phase, although one author has suggested eliminating noncontrast scans from all surveillance examinations with the exception of an initial 1-month follow-up.

Several studies have reported significant dose reduction using dual-energy CT with acquisition of delayed-phase images only. Accompanying software allows for the isolation of iodine from a selected region and enables reconstruction of virtual noncontrast images. A colored overlay can be applied to voxels containing iodine, rendering detection of contrast material within the aneurysm sac external to the stent-graft more visible. Dual-phase dual-energy CT can potentially reduce the radiation dose by 19.5% when compared to a standard triphasic CT examination. Additional dose reduction techniques include the use of automatic exposure control and iterative reconstruction algorithms.

Determining the optimal dose-efficient CT technique is a work in progress that will continue to evolve with increased experience and technological advancement.

Aortography

Aortography is an invasive imaging modality that can accurately assess aortic side branch patency, knowledge of which is crucial for deployment of conventional and fenestrated endografts with or without bridging stents. However, it fails to demonstrate mural thrombus, thereby limiting diameter measurements and landing zone assessment. Though less sensitive than CTA in detecting endoleaks, aortography is able to demonstrate the direction of blood flow in or out of the aneurysm sac, rendering it more accurate than CTA in classifying endoleaks. Although traditional aortography relies on iodinated

contrast material, recent studies suggest that carbon dioxide may be an acceptable alternative for evaluating endoleaks in patients at risk for contrast-related nephropathy.

MRA

The major advantage of magnetic resonance angiography (MRA) relative to CTA is improved soft tissue characterization. Despite relatively low nephrotoxicity, gadolinium-based contrast media (GBCM) have been linked to nephrogenic systemic fibrosis (NSF). As such, evaluation of renal function in high-risk patients before administering a GBCM is recommended. Disadvantages of MRA include relatively long scanning duration, patient claustrophobia, decreased spatial resolution, and contraindication in patients with certain implantable devices. MRA is also limited in its ability to detect intimal calcification. Additionally, susceptibility artifact from the metal interstices of the stent graft presents a diagnostic challenge for assessing device integrity and may mimic graft stenosis. Although the presence of an implanted cardiac pacemaker was previously an absolute contraindication to magnetic resonance imaging (MRI), several new models are FDA-approved for conditional use.

Superior soft-tissue characterization inherent to MRA may assist clinicians in differentiating slow-growing aneurysms from fast-growing aneurysms. A recent study demonstrated that AAAs containing intraluminal thrombus that have high T1-weighted signal intensity are associated with higher growth rates.

US

Color duplex ultrasound (CDUS) is a noninvasive imaging modality that is portable and safe, sparing patients from nephrotoxic contrast material administration. CDUS is able to assess blood flow dynamics in real-time and allows for quantification of luminal diameter and cross-sectional area. Image quality in CDUS is highly dependent on operator experience, patient cooperation, and patient body habitus. Although excellent correlation between AAA diameter measurements made by CT and CDUS is well documented, there is general agreement that conventional ultrasound (US) techniques systematically underestimate aneurysm diameter by ~2 mm.

Contrast-enhanced ultrasound (CEUS) utilizes the infusion of stabilized sodium hexafluoride gas to visualize the vessel lumen. Unlike iodinated contrast materials used in CTA, this gas is not nephrotoxic and is safely eliminated via the respiratory system. The advent of 3-D CEUS utilizes positional information for magnetic field emitters to assemble collected US reflections into a high-resolution 3-D image, which results in improved image quality relative to CDUS. 3-D CEUS is reported to be more accurate than 2-D methods in quantifying maximum vessel diameter, as the former allows measurements to be made orthogonal to vessel centerline.

For patients with absolute contraindications to iodinated contrast material, whether due to severe renal impairment or life-threatening contrast allergy, US is an important adjunct to nonenhanced CT.

Discussion of Procedures by Variant

Variant 1: Planning for Pre-endovascular Repair (EVAR) or Open Repair of AAA

Radiography

Radiographs are unable to adequately visualize the abdominal aorta, thereby prohibiting proximal landing zone assessment and luminal diameter quantification. As such, there is no role for radiography in the preoperative evaluation of AAA. However, given the high spatial resolution of radiography, this modality affords optimal visualization of stent graft geometry. When utilizing consistent centering protocols, this allows for reliable detection of kinks and stent graft migration to within 2 mm.

CT and CTA

Due to its superior spatial resolution and rapid image acquisition, CTA with 3-D volumetric reconstruction and vessel analysis has gained wide acceptance as the gold standard for pre-EVAR evaluation. The utilization of 3-D reconstruction software has become paramount in EVAR planning, as it diminishes the impact of vessel tortuosity on diameter and length measurements, in addition to reducing intraobserver

variability. One author found that routine 3-D analysis of pre-EVAR images led to a significant reduction in type I endoleaks. Reformatted CTA images in the coronal and sagittal planes should be utilized for increased diagnostic accuracy. In most cases, a CTA of the abdomen and pelvis is appropriate to ensure coverage of the entire aneurysm and vascular access. The CTA should include the chest in patients with thoracoabdominal aortic aneurysms (TAAA).

Aortography

As aortography and radiography are unable to accurately provide aneurysm sac diameter measurements and landing zone assessment, these modalities are inadequate for pre-EVAR or open repair evaluation. However, aortography may be of value in assessing branch vessel patency and is usually part of branch vessel occlusion procedures before aneurysm repair.

MRA

For the purpose of pre-EVAR planning, T1-weighted spin-echo images and flow-based methods such as time of flight or phase contrast provide adequate details regarding aneurysm morphology and relevant vascular anatomy. However, these techniques are limited by low spatial resolution and signal-to-noise ratio and are therefore suboptimal for evaluating small-vessel lesions or diminutive side branches. Furthermore, flow-based sequences are susceptible to flow artifacts that may overestimate the degree of stenosis or falsely demonstrate an occlusion. To overcome these limitations, contrast-enhanced MRA (CE-MRA) should be added to conventional T1- and T2-weighted spin-echo sequences. CE-MRA is much less susceptible to flow and susceptibility artifacts and has a high signal-to-noise ratio for evaluating small vessels and fine structural details. The effectiveness of CE-MRA has been found to be comparable to that of CTA in assessing the suitability of aneurysms for EVAR. In most cases, an MRA of the abdomen and pelvis is appropriate to ensure coverage of the entire aneurysm and vascular access. The MRA should include the chest in patients with TAAA.

Acquisition of noncontrast balanced steady state free precession (bSSFP) images may be useful in the preoperative evaluation of patients who poorly tolerate GBCM or are at risk for NSF. One study found that AAA measurements obtained by noncontrast MRA were not significantly different from those measured by CTA.

US

Although the United States Preventative Services Task Force currently recommends one-time US screening for AAA in men ages 65 to 75 years who have ever smoked, no evidence is present within the medical literature to support the use of either CDUS or CEUS in the formal preoperative evaluation of AAA.

Variant 2: Follow-up for Post-endovascular Repair (EVAR) or Open Repair of AAA

CT and CTA

The exceptional spatial resolution and fast imaging speeds of CTA has made it the de facto gold standard for post-EVAR and post-open repair imaging surveillance. After EVAR, the most widely used surveillance regimen utilizes multiphasic contrast-enhanced CT at 1 month, 12 months, and yearly thereafter. If an abnormality is detected 1 month post-EVAR, a follow-up scan at 6 months is performed. In the absence of adverse outcomes at the 1-month follow-up imaging, the intensity and frequency of the surveillance program may be modulated accordingly. Compared to aortography, CTA has higher sensitivity in detecting endoleaks after EVAR. Compared to US, CTA is better able to visualize kinking and migration of the stent-graft and is equivalent in quantifying aneurysm sac size.

Initial post-EVAR surveillance studies monitored the maximum diameter of the aneurysm sac as a marker for response to therapy. This method has been shown to be unreliable due to substantial interobserver variability. Volume analysis of the aneurysm sac has since proven to be the most reliable indicator for aneurysm rupture and/or need for reintervention. In an effort to reduce radiation dose and contrast material exposure, several authors have proposed using serial volumetric analysis of AAAs with noncontrast CT as the sole screening test for post-EVAR follow-up. Volume discrepancy due to

interoperator variability has been demonstrated to be less than 2% when the procedure is performed by experienced personnel. In patients in whom contrast materials are contraindicated, serial volume measurements of the nonenhanced aneurysm sac provides valuable information in guiding management.

In most cases, a CTA of the abdomen and pelvis is appropriate to ensure coverage of the treated aneurysm and stent graft. The CTA should include the chest in patients with TAAA.

Aortography

Due to the relatively invasive nature of aortography, it is not practical for routine post-EVAR surveillance. However, in the setting of a known endoleak, aortography may be more accurate than CTA in classifying endoleaks. One study revealed only 86% agreement in endoleak classification between aortography and CTA, in which subsequent correct classification by aortography significantly improved patient management. It therefore stands to reason that aortography may be best utilized as a second-line imaging modality in post-EVAR patients, playing a vital role in endoleak classification and reintervention.

MRA

When considering using MRA for post-EVAR surveillance, stent material and orientation are important considerations. Typical stent construction employs nitinol, elgiloy, or stainless steel. Nitinol is a nickel-titanium alloy that causes relatively few artifacts on MRA, while allowing adequate visualization of the stent lumen and adjacent structures. Elgiloy is an alloy of cobalt, chromium, and nickel that may obscure the stent lumen but still allows for visualization of adjacent structures. Patients with nitinol stents are the optimal candidates for MRA, while those with elgiloy or stainless steel stents may experience significant artifacts that compromise visualization of the stent lumen and limit morphological resolution of the stent wall. However, artifacts may arise even with nitinol stents secondary to stent geometry. Due to severe susceptibility artifact associated with stainless steel embolization coils, MRA is poor in the follow-up of patients who have undergone coil embolization of the internal iliac artery before EVAR.

MRA of the post-EVAR aorta shares multiple features with CTA. Like CTA, isotropic 3-D MRA images may be reformatted in any plane for volume analysis or orthogonal diameter measurements. In patients with nitinol stents, aortic diameter measurements for MRA have been shown to be as reliable as those obtained with CTA. MRA has been shown to be more sensitive than CTA for the detection of endoleaks. Consequently, the higher rate of endoleak detection seen by MRA in cases with a negative CTA may shed light on the phenomenon of endotension. More recently, time-resolved MRA has been used in the characterization of endoleaks and may provide relevant information regarding contrast and flow dynamics within endoleaks. As such, replacing aortography as an effective and noninvasive method for endoleak characterization shows promise.

In most cases, MRA of the abdomen and pelvis is appropriate to ensure coverage of the treated aneurysm and stent graft. The MRA should include the chest in patients with TAAA.

Blood pool contrast materials such as ferumoxytol remain intravascular for a prolonged duration, thereby allowing for generation of high-resolution 3-D multiplanar images. Use of these contrast materials may improve detection of slow-flow endoleaks.

Patients intolerant of GBCM or those at risk for NSF may benefit from the acquisition of noncontrast bSSFP images in post-EVAR surveillance. One small retrospective study found that noncontrast bSSFP images can be used to exclude endoleak after EVAR, with postcontrast imaging reserved for verification and further characterization of a suspected endoleak.

US

CDUS and CEUS are being increasingly recommended for post-EVAR follow-up. These are convenient, noninvasive, and have a favorable safety profile. In the evaluation of endoleak, CDUS has high specificity but limited sensitivity, reported in two large meta-analyses to be 91% to 93% and 66% to 69%, respectively. The major limitations of US are the inability to detect stent-graft kinking, fracture, migration, or component separation. For this reason, adjunct four-view radiographs are recommended to

be obtained with all post-EVAR US examinations. For FEVARs that involve the celiac trunk, US is unable to adequately visualize the proximal sealing zone.

Not unexpectedly, published results regarding the accuracy of CDUS in post-EVAR follow-up are varied. Nevertheless, US offers the ability to determine endoleak flow direction and therefore assist in guiding management. Spectral waveform analysis of reperfusion to the aneurysm sac has been shown to have prognostic value, in which type II endoleaks with bidirectional flow and low flow velocities have been associated with spontaneous closure.

Several studies have compared 2-D CEUS to CDUS in the setting of post-EVAR follow-up, with a recent meta-analysis finding no clinically significant differences between the two. In the setting of post-FEVAR follow-up, 2-D CEUS was found to be equivalent to CTA in aneurysm sac measurement and in assessing patency of visceral vessels. Additional studies have demonstrated the superiority of 3-D CEUS over standard 2-D methods in both endoleak detection and sac measurement. Three-dimensional CEUS has been found to be equivalent or superior to CTA in endoleak detection and sac measurement, in addition to being highly reproducible.

Many have advocated replacing CTA with US for post-EVAR surveillance due to its lack of exposure to nephrotoxic contrast. Specifically, it has been suggested that CDUS be used in conjunction with noncontrast CT to follow patient's post-EVAR who have renal insufficiency. US surveillance protocols currently being developed seek to drastically reduce the cost of follow-up without compromising accuracy, with CTA reserved for further evaluation of suspicious findings.

Radiography

Radiographs were previously considered a useful adjunct to CT for detecting stent graft migration and underlying structural change. This modality cannot be used as a stand-alone study, as it is unable to assess aneurysm sac size or detect endoleak. Radiography alone therefore does not meet guideline criteria outlined by the Society of Interventional Radiology in AAA postoperative surveillance. Despite its limitations, anterior and lateral radiographs have been shown to be useful for detecting stent migration, kinking, or modular separation of the stent graft components, whereas oblique projections may detect wire fractures. Three-dimensional–reconstructed CTA images also provide this information, in addition to detecting endoleaks and changes in aneurysm size. As such, advances in 3-D visualization tools will likely render radiographs redundant and unnecessary when used in conjunction with CT. However, if US is used as the primary imaging modality in post-EVAR surveillance, radiographs become a vital adjunct examination.

Summary of Recommendations

For preoperative AAA repair planning, CTA abdomen and pelvis and MRA abdomen and pelvis are appropriate procedures.
After repair of AAA, CTA abdomen and pelvis and MRA abdomen and pelvis are appropriate procedures.

Abbreviations

AAA, abdominal aortic aneurysm
CT, computed tomography
CTA, computed tomography angiography
EVAR, endovascular aneurysm repair
IV, intravenous
MRA, magnetic resonance angiography
US, ultrasound

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Abdominal aortic aneurysm (AAA)

Guideline Category

Evaluation

Management

Screening

Treatment

Clinical Specialty

Cardiology

Family Practice

Internal Medicine

Radiology

Thoracic Surgery

Intended Users

Advanced Practice Nurses

Health Care Providers

Hospitals

Managed Care Organizations

Physician Assistants

Physicians

Students

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of imaging procedures for interventional planning and follow-up of abdominal aortic aneurysm (AAA)

Target Population

Patients with an abdominal aortic aneurysm

Interventions and Practices Considered

1. Computed tomography angiography (CTA), abdomen and pelvis with intravenous (IV) contrast
2. Computed tomography (CT)
    - Abdomen and pelvis without IV contrast
    - Abdomen and pelvis with IV contrast
    - Abdomen and pelvis without and with IV contrast
3. Magnetic resonance angiography (MRA)
    - Abdomen and pelvis without and with IV contrast
    - Abdomen and pelvis without IV contrast
4. Aortography, abdomen
5. Ultrasound (US) aorta abdomen with duplex Doppler
6. X-ray, abdomen and pelvis
7. CT abdomen and pelvis without IV contrast and US aorta abdomen with duplex Doppler

Major Outcomes Considered

- Utility of imaging procedures in interventional planning and follow-up of abdominal aortic aneurysm
- Sensitivity, specificity, and accuracy of imaging procedures in interventional planning and follow-up of abdominal aortic aneurysm

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Summary

Of the 70 citations in the original bibliography, 60 were retained in the final document.

A literature search was conducted in April 2015 and updated on August 2017 to identify additional evidence published since the *ACR Appropriateness Criteria® Abdominal Aortic Aneurysm: Interventional Planning and Follow-up* topic was finalized. Using the search strategy described in the literature search companion (see the "Availability of Companion Documents" field), 889 articles were found. 34 articles were added to the bibliography. One hundred and thirty-three articles were not used as they were duplicates already cited in the original bibliography or captured in more than one literature search. The remaining articles were not used due to either poor study design, the articles were not relevant or generalizable to the topic, or the results were unclear or biased.

The author added 3 citations from bibliographies, Web sites, or books that were not found in the literature searches.

Three citations are supporting documents that were added by staff.

See also the American College of Radiology (ACR) Appropriateness Criteria® literature search process document (see the "Availability of Companion Documents" field) for further information.

Number of Source Documents

Of the 70 citations in the original bibliography, 60 were retained in the final document. The literature search conducted in April 2015 and updated in August 2017 found 34 articles that were added to the bibliography. The author added 3 citations from bibliographies, Web sites, or books that were not found in the literature searches. Three citations are supporting documents that were added by staff.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Definitions of Study Quality Categories

Category 1 - The study is well-designed and accounts for common biases.

Category 2 - The study is moderately well-designed and accounts for most common biases.

Category 3 - The study has important study design limitations.

Category 4 - The study or source is not useful as primary evidence. The article may not be a clinical study, the study design is invalid, or conclusions are based on expert consensus.

> The study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
>
> *Or*
>
> The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
>
> *Or*
>
> The study is an expert opinion or consensus document.

Category M - Meta-analysis studies are not rated for study quality using the study element method because the method is designed to evaluate individual studies only. An "M" for the study quality will indicate that the study quality has not been evaluated for the meta-analysis study.

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author assesses the literature then drafts or revises the narrative summarizing the evidence found in the literature. American College of Radiology (ACR) staff drafts an evidence table based on the analysis of the selected literature. These tables rate the study quality for each article included in the narrative.

The expert panel reviews the narrative, evidence table and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the variant table(s). Each individual panel member assigns a rating based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Overview

The purpose of the rating rounds is to systematically and transparently determine the panels' recommendations while mitigating any undue influence of one or more panel members on another individual panel members' interpretation of the evidence. The panel member's rating is determined by reviewing the evidence presented in the Summary of Literature Review and assessing the risks or harms of performing the procedure or treatment balanced with the benefits of performing the procedure or treatment. The individual panel member ratings are used to calculate the median rating, which determines the panel's rating. The assessment of the amount of deviation of individual ratings from the panel rating determines whether there is disagreement among the panel about the rating.

The process used in the rating rounds is a modified Delphi method based on the methodology described in the RAND/UCLA Appropriateness Method User Manual.

The appropriateness is rated on an ordinal scale that uses integers from 1 to 9 grouped into three categories (see the "Rating Scheme for the Strength of the Recommendations" field).

Determining the Panel's Recommendation

> Ratings represent an individual's assessment of the risks and benefits of performing a specific procedure for a specific clinical scenario on an ordinal scale. The recommendation is the appropriateness category (i.e., "Usually appropriate," "May be appropriate," or "Usually not appropriate").
> The appropriateness category for a procedure and clinical scenario is determined by the panel's median rating without disagreement (see below for definition of disagreement). The panel's median rating is calculated after each rating round. If there is disagreement after the second rating round, the rating category is "May be appropriate (Disagreement)" with a rating of "5" so users understand the group disagreed on the final recommendation. The actual panel median rating is documented to provide additional context.

Disagreement is defined as excessive dispersion of the individual ratings from the group (in this case, an Appropriateness Criteria [AC] panel) median as determined by comparison of the interpercentile range (IPR) and the interpercentile range adjusted for symmetry (IPRAS). In those instances when the IPR is greater than the IPRAS, there is disagreement. For a complete discussion, please refer to chapter 8 of the RAND/UCLA Appropriateness Method User Manual.
Once the final recommendations have been determined, the panel reviews the document. If two thirds of the panel feel a final recommendation is wrong (e.g., does not accurately reflect the evidence, may negatively impact patient health, has unintended consequences that may harm health care, etc.) and the process must be started again from the beginning.

For additional information on the ratings process see the Rating Round Information document (see the "Availability of Companion Documents" field).

Additional methodology documents, including a more detailed explanation of the complete topic development process and all ACR AC topics can be found on the ACR Web site (see also the "Availability of Companion Documents" field).

Rating Scheme for the Strength of the Recommendations

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current medical evidence literature and the application of the RAND/UCLA appropriateness method and expert panel consensus.

Summary of Evidence

Of the 100 references cited in the *ACR Appropriateness Criteria® Abdominal Aortic Aneurysm: Interventional Planning and Follow-up* document, 16 are categorized as therapeutic references, including 5 well-designed studies, 8 good-quality studies. Additionally, 80 references are categorized as diagnostic references including 4 well-designed studies, 15 good-quality studies, and 30 quality studies that may have design limitations. There are 34 references that may not be useful as primary evidence. There are 4 references that are meta-analysis studies.

Although there are references that report on studies with design limitations, 32 well-designed or good-quality studies provide good evidence.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

- Patients intolerant of gadolinium-based contrast media (GBCM) or those at risk for nephrogenic systemic fibrosis (NSF) may benefit from the acquisition of noncontrast balanced steady state free precession (bSSFP) images in post-endovascular repair (EVAR) surveillance.
- Blood pool contrast materials such as ferumoxytol remain intravascular for a prolonged duration, thereby allowing for generation of high-resolution 3-D multiplanar images. Use of these contrast materials may improve detection of slow-flow endoleaks.
- The ultimate goal of endovascular therapy is to prevent aneurysm rupture. Follow-up imaging is the most useful tool for evaluating post-therapeutic outcomes and monitoring potential complications. Successful therapy results in an aneurysm that remains stable or decreases in size over serial follow-up imaging examinations, with decreasing size of the aneurysm sac believed to indicate a low risk of future rupture.

Potential Harms

- A disadvantage of computed tomography angiography (CTA) includes potential nephrotoxicity from administered contrast material.
- Disadvantages of magnetic resonance angiography (MRA) include relatively long scanning duration, patient claustrophobia, decreased spatial resolution, and contraindication in patients with certain implantable devices. MRA is also limited in its ability to detect intimal calcification. Additionally, susceptibility artifact from the metal interstices of the stent graft presents a diagnostic challenge for assessing device integrity and may mimic graft stenosis.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation

exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the American College of Radiology (ACR) Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Contraindications

Contraindications

- Although not an absolute contraindication to endovascular aneurysm repair (EVAR), mural thrombus and atherosclerotic calcification covering more than 90° of the circumference of the aortic diameter in the proximal neck is associated with a higher risk for type I endoleak and stent-graft migration.
- Magnetic resonance angiography (MRA) is contraindicated in patients with certain implantable devices. Although the presence of an implanted cardiac pacemaker was previously an absolute contraindication to magnetic resonance imaging (MRI), several new models are U.S. Food and Drug Administration (FDA)-approved for conditional use.
- Severe renal impairment and life-threatening contrast allergy are contraindications to iodinated contrast.

Qualifying Statements

Qualifying Statements

- The American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.
- ACR seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply society endorsement of the final document.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Living with Illness

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Francois CJ, Skulborstad EP, Majdalany BS, Chandra A, Collins JD, Farsad K, Gerhard-Herman MD, Gornik HL, Kendi AT, Khaja MS, Lee MH, Sutphin PD, Kapoor BS, Kalva SP, Expert Panels on Vascular Imaging and Interventional Radiology. ACR Appropriateness CriteriaÂ® abdominal aortic aneurysm: interventional planning and follow-up. Reston (VA): American College of Radiology (ACR); 2017. 13 p. [100 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2017

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

The funding for the process is assumed entirely by the American College of Radiology (ACR). ACR staff support the expert panels through the conduct of literature searches, acquisition of scientific articles, drafting of evidence tables, dissemination of materials for the Delphi process, collation of results, conference calls, document processing, and general assistance to the panelists.

Guideline Committee

Committee on Appropriateness Criteria, Expert Panels on Vascular Imaging and Interventional Radiology

Composition of Group That Authored the Guideline

Panel Members: Christopher J. Francois, MD (*Principal Author*); Erik P. Skulborstad, MD, MBA (*Research Author*); Bill S. Majdalany, MD (*Panel Vice-chair [Vascular]*); Ankur Chandra, MD; Jeremy D. Collins, MD; Khashayar Farsad, MD, PhD; Marie D. Gerhard-Herman, MD; Heather L. Gornik, MD; A. Tuba Kendi, MD; Minhajuddin S. Khaja, MD, MBA; Margaret H. Lee, MD; Patrick D. Sutphin, MD, PhD; Baljendra S. Kapoor, MD (*Panel Chair [Interventional]*); Sanjeeva P. Kalva, MD (*Panel Chair [Vascular]*)

Financial Disclosures/Conflicts of Interest

Disclosing Potential Conflicts of Interest and Management of Conflicts of Interest

An important aspect of committee operations is the disclosure and management of potential conflicts of interest. In 2016, the American College of Radiology (ACR) began an organization-wide review of its conflict of interest (COI) policies. The current ACR COI policy is available on its Web site. The Appropriateness Criteria (AC) program's COI process varies from the organization's current policy to accommodate the requirements for qualified provider-led entities as designated by the Centers for Medicare and Medicaid Services' Appropriate Use Criteria (AUC) program.

When physicians become participants in the AC program, welcome letters are sent to inform them of their panel roles and responsibilities, including a link to complete the COI form. The COI form requires disclosure of all potential conflicts of interest. ACR staff oversees the COI evaluation process, coordinating with review panels consisting of ACR staff and members, who determine when there is a conflict of interest and what action, if any, is appropriate. In addition to making the information publicly available, management may include exclusion from some topic processes, exclusion from a topic, or exclusion from the panel.

Besides potential COI disclosure, AC staff begins every committee call with the conflict of interest disclosure statement listed below reminding members to update their COI forms. If any updates to their COI information have not been submitted, they are instructed not to participate in discussion where an undisclosed conflict may exist.

Finally, all ACR AC are published as part of the Journal of the American College of Radiology (JACR) electronic supplement. Those who participated on the document and are listed as authors must complete the JACR process that includes completing the International Committee of Medical Journal Editors (ICMJE) COI form which is reviewed by the journal's staff/publisher.

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Francois CJ, Kramer JH, Rybicki FJ, Ray CE Jr, Bandyk DF, Burke CT, Dill KE, Gerhard-Herman MD, Hanley M, Hohenwalter EJ, Mohler ER III, Rochon PJ, Schenker MP, Expert Panel on Vascular Imaging and Interventional Radiology. ACR Appropriateness Criteria® abdominal aortic aneurysm: interventional planning and follow-up. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 8 p. [71 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Available from the American College of Radiology (ACR) Web site.

Availability of Companion Documents

The following are available:

ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2017. Available from the American College of Radiology (ACR) Web site .
ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 2015 Feb. 1 p. Available from the ACR Web site .
ACR Appropriateness Criteria®. Evidence table development. Reston (VA): American College of Radiology; 2015 Nov. 5 p. Available from the ACR Web site .
ACR Appropriateness Criteria®. Topic development process. Reston (VA): American College of Radiology; 2015 Nov. 2 p. Available from the ACR Web site .
ACR Appropriateness Criteria®. Rating round information. Reston (VA): American College of Radiology; 2017 Sep. 5 p. Available from the ACR Web site .
ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2018. 4 p. Available from the ACR Web site .
ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 2017. 125 p. Available from the ACR Web site .
ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 2017 Mar. 4 p. Available from the ACR Web site .
ACR Appropriateness Criteria® abdominal aortic aneurysm: interventional planning and follow-up. Evidence table. Reston (VA): American College of Radiology; 2017. 52 p. Available from the ACR Web site .
ACR Appropriateness Criteria® abdominal aortic aneurysm: interventional planning and follow-up. Literature search summary. Reston (VA): American College of Radiology; 2017. 2 p. Available from the ACR Web site .

Patient Resources

None available

NGC Status

This summary was completed by ECRI Institute on September 8, 2011. The guideline developer agreed to not review the content. This summary was updated by ECRI Institute on April 17, 2013. The guideline developer agreed to not review the content. This summary was updated again by ECRI Institute on May 14, 2018. The guideline developer agreed to not review the content.

This NEATS assessment was completed by ECRI Institute on May 10, 2018. The information was verified by the guideline developer on June 1, 2018.

Copyright Statement

Disclaimer

NGC Disclaimer

agencies, health care organizations or plans, and similar entities.

Guidelines represented on the NGC Web site are submitted by guideline developers, and are screened solely to determine that they meet the NGC Inclusion Criteria.

NGC, AHRQ, and its contractor ECRI Institute make no warranties concerning the content or clinical efficacy or effectiveness of the clinical practice guidelines and related materials represented on this site. Moreover, the views and opinions of developers or authors of guidelines represented on this site do not necessarily state or reflect those of NGC, AHRQ, or its contractor ECRI Institute, and inclusion or hosting of guidelines in NGC may not be used for advertising or commercial endorsement purposes.

Readers with questions regarding guideline content are directed to contact the guideline developer.